RENEWABLE ENERGY SYSTEM FOR DEPLOYMENT ON HIGHWAY AND ITS APPLICATIONS

Synopsis

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Submitted by

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1. Introduction

Mitigating increased environmental pollution causing poor air quality is a growing challenge these days. The accumulation of greenhouse gases, depletion of the ozone layer, increased level of smaller size particulate matter ($PM_{2.5}$ and lower), and increased concentration of pollutants are major challenges of this century. With the onset of the Covid-19 pandemic, the poor environmental condition had also contributed towards increased casualty of human life and had also affected the future development of any country. Climate Change Accords to mitigate these effects in particular and the effects of global warming, in general, are yet to create sufficient impact to be effective. Perhaps, the only way ahead is to invest in efforts that are conducive to improving the environment and reduce sources of pollution. One of the major factors of concern is vehicular pollution. The present road transportation system is largely dependent on vehicles that are driven by polluting fossil fuels. With the increased traffic of polluting vehicles, the total emissions will be more and will cause more harm tothe environment. To address this problem and minimize the impact of flue gases emanated from the burning of fossil fuels in the engine, there is a strong need of switching to an alternate fuel or system. In India, roughly 8.5 billion square meters of land is occupied by roadways. Approximately 30% are under ill-lightning. Vehicles on such asphalt roads that consume fossil fuel Exceed a large amount of carbon monoxide and other greenhouse gases, which raises a large amount of carbon footprint. Solar photovoltaic (PV) is a green technology capable of forming a cleanly efficient, scalable, and affordable energy system for the future. In this regard, the governments of most countries are promoting the production and deployment of solar photovoltaic (PV) technology. This technology can also make emerging electric vehicles even more affordable and manageable [1].India stands third in Asia and fourth on the planet regarding sun-light based force creation across its plants. This presently represents about 38% of its absolute limit of sustainable power. The nation likewise claims to possess the world's biggest solar-based park, situated in Rajasthan. India's Public Sunlight based Mission dispatched in 2010 — when only 10MW of solar-based force was introduced with an objective of 20GW set for the decade's end. In any case, because of critical action inside the solar-based force area throughout the years to come, India has raised its objective by a few indents and now means to accomplish 100GW of solar-based force limit by 2022. Reported to be the largest solar power plant in

the world, Bhadla Solar Park is located in the village of Bhadla, in the Jodhpur district of Rajasthan. A fully operational power plant with a capacity of almost 2,250 megawatts has been designed, spanning 14,000 acres (MW). Rajasthan plans to set up 30,000 MW of solar power plants over the next five years.

Fig -1 Solar power plant in Rajasthan
(Source : https://economictime.com)

The largest fully operational solar park till the end of 2019, the 2,050MW Shakti Sthala solar power project in Pavagada taluk, Tumakuru district, Karnataka, is also now India's second-largest solar powerplant after Rajasthan Bhadla. The Pavagada Solar Park occupies more than 13,000 acres of land. Located in Orvakal, Kurnool district, Andhra Pradesh, another leading Indian state in terms of solar power, the 1,000 MW Ultra Mega Solar National park is located on more than 5,932 acres and is the third biggest known solar power installation. A 1,500 MW solar park is set to become operational in the neighboring. district of Kadapa, followed by two larger solar power plants, which could increase the state's solar energy potential by an additional 2,750 MW. This gigantic project, which is one of the largest unique projects in the world, will be a reward for the farming community's assurance and efficiency of daytime power supply.

Fig 2 – Ultra mega solar power plant in Andhra Pradesh
(Source : https://www.deccanherald.com/content/358523/worlds-largest-solar-power-plant)

The 750MW Rewa Solar Power Project of Madhya Pradesh is spread over an area of 1,590 acres and is operated by Rewa Ultra Mega Solar Ltd. Kamuthi, in Ramanathapuram district of the southern state of Tamil Nadu home to India's fifth-largest solar power plant. The 648MW capacity plant is connected to the 400KV Kamuthi substation of Tamil Nadu Transmission Corporation, which distributes power to approximately 265,000 homes.[1]. Cochin International Airport in Kerala sets an example for the rest of the world by contributing to the climate. The airport was packed in a tender that required it to set up a 12 MW solar power project within the airport complex on a total of 45 acres previously allocated to the cargo handling unit.

Fig 3- Cochin International Airport in Kerala
Source : Businesstoday.in

Kolkata airport now has a fully-functional solar plant that will be used for day-to-day operations. The 15 MW ground-mounted and grid-connected solar plant at the airport is now fully operational[2].

Fig 4- Kolkata Airport
Source : www.saurenergy.com

Moving in such a direction is possible only if suitable vehicles are developed and infrastructure is in place. As technological progress in the electrification of two/three-wheelers, buses, and trucks advances and the market for them grows, electric vehicles are expanding significantly.

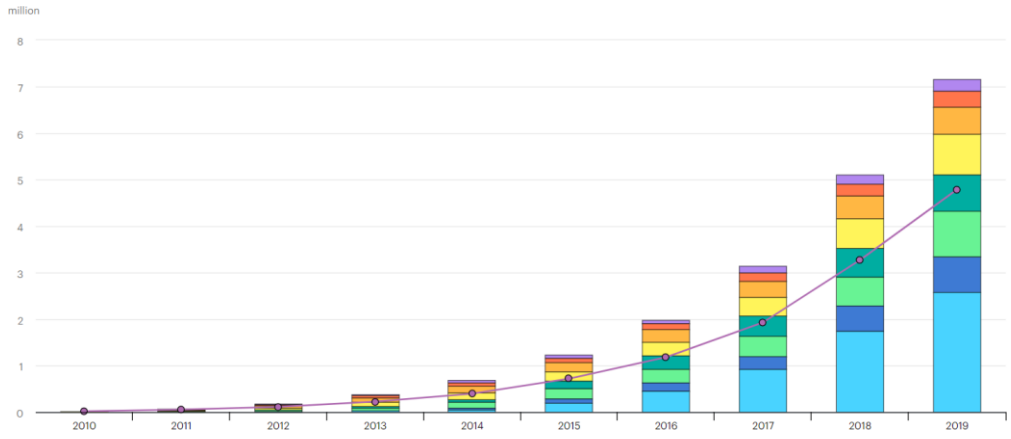

Fig 5-Global Stock of Electric Cars from 2010 to 2019
(Source : Global EV Outlook 2020, IEA)

The above figure presents the global stock of electric cars from 2010 to 2019. Electrical vehicles, both four-wheelers, and two-wheelers are being manufactured and are available in an open market for consumers to get an advantage of. Electric cars, which accounted for 2.6% of global car sa1% of global car stock in 2019, registered a 40% year-on-year increase. Global sales of electric trucks hit a record in 2019 with over 6000 units, while the number of models continues to expand. High-power chargers are being developed and standardized globally. Research on dynamic charging concepts, as

well as demonstrations of catenary line solutions, may enable expansion of the range of operations for heavy-duty and long-distance operations for regional buses and long-haul trucking [2].

[2] IEA, Global electric car stock, 2010-2019, IEA, Paris https://www.iea.org/data-and-statistics/charts/global-electric-car-stock-2010-2019

For making long-distance, heavy load carrying electric vehicles a reality, road infrastructure has to be developed to facilitate such transportation. Such an infrastructure is termed as the electric highway of E-Highway in its most general meaning. The E_Highway system was initially introduced to the electric utilities primarily to transport electric energy. The new definition associated with E-Highway and implementing it on the core highway for transportation system will provide a solution to drive different types of vehicles (e.g automated and autonomous electric passenger and cargo vehicles).

Because of the impending threat of global warming, every country is viewing to reduce carbon

Fig 6- E.Highway
(Source : https://www.indiatimes.com)

emissions by switching to electrical energy based transportation. With an ever-increasing interest in cleaner transport, efforts to develop a proficient strategy or framework are being developed and implemented in many European countries and others are closely following. Global warming, deforestation, and fossil fuel depletion are some of today's modern greatest issues, and policymakers around the world are working hard to find viable ways to overcome these challenges. The EU currently has some of the strictest vehicle emissions regulations, and numerous European countries have committed to reducing their carbon footprints over the coming years. To solve the problem, Germany has established a genius solution - an electrified highway for electric heavy trucks. The

system built by Siemens uses overhead cables to allow trucks to draw power from their electric motors on the 5 km stretch of the A5 motorway in Hessen, effectively translating these trucks on the route into zero diesel emissions. The trucks will turn to their hybrid power plants when they do not move on the 'E.Highway.' Sweden has opened the world's first electric highway for trucks fitted with hybrid engines to test a potential low-carbon road freight route. It works similarly as a tram,utilizing overhead lines got to with extendible pantographs. The lines are provided by Siemens and the trucks, which are fitted with hybrid electric-diesel engines, are made by Scania. Every nation seeks a future that does not require non-renewable energy sources. As there is an assumed development of interest in transport, the amount of outflow of carbon dioxide is more than that of the country's economy. To limit the impact of the petroleum derivative gases, another, innocuous what's more, a proficient strategy or framework should be drilled. The E-Highway framework is presented with such a motto. ERS is basically, the electric streets empower to the vehicles making a course for performing utilizing, power source coordinated into the street surface by remotely driving energy to an electric motor. This roadway improved crossover trucks are furnished with power from overhead association lines through a powerful pantograph, which can couple and uncouple the overhead links to rates of up to 90 kmph. In ERS, a two-pole framework is a practice so not just power in-feed yet also power out- feed can be overseen while in trains overhead transmission innovation is utilized to deal with the bring circuit back. 80 to 85% accomplished in the direct transmission of electric energy to the wheels. This framework empowers to recover the slowing down energy and reinforcement it locally available or feed to different trucks following the framework or overabundance into the public framework. At the point when executed on courses with adequate volumes of traffic, solid returns. The E-Highway framework is in this manner solid and open-standard contact-line innovation that doesn't interfere with the outside of the street. When contrasting all alternatives, an overhead contact line framework contains a basic spine of the savviest." Pantograph' is a word gotten from the Greek language, which implies, 'everyone writes'. It is a structure with mechanical linkage in this manner it works by framing a parallelogram [3], the pantograph is a leading arm expanding over the moving stock, gathering foothold current from the Over-headed line framework. Present-day Pantograph guideline is gotten from connected help structures called "Scissors system". The framework is utilized to connect with

wire or then again link overhead. Contingent upon the train speed, pantographs come in all shapes and sizes [4]. A pantograph's fundamental parts are a lower arm(s) turning against the top of a carriage/loco and joined to the upper arm appended to the head or skillet of an authority. The head is the pantographer's just part to contact the pick - up wire. The current is accumulated on the head through metalized carbon strips. They are altogether characterized into three kinds, for example, a. Bow gatherer, b. Streetcar shaft and c. Pantograph [5].With solar panels, mapping sensors, and electric battery rechargers, the road to China's self-governing driving future is cleared as the country tests an "insightful expressway" that could speed up the change in the worldwide transport industry.

Fig 7- The Two Lanes of Solar Panels. (Source : electric.com)

The advances will be installed under straightforward cement used to fabricate a 1,080-meter-long street in the eastern city of Jinan. According to builder Qilu Transportation Development Group Co., about 45,000 vehicles barrel over the section every day and the solar panels inside generate enough electricity to power highway lights and 800 homes. The solar panels spread across two paths, which feel indistinguishable to a driver than the customary street, and are more slender than a 1-yuan coin remaining on its edge. Sweden has opened the world's initially charged street. The 1.2-mile course, between Stockholm Arlanda air terminal and a coordination site, will currently effectively charge vehicles and lorries as they travel along it utilizing a creative energy move framework.

Fig 8-Electrified Road (Source : https://inhabitat.com)

The mechanism works by transmitting electricity through a flexible arm that connects to the charging vehicle from the mounted underground rail to the vehicle above."There are two tracks, like the outlet of the wall. Five to six inches down is where there's energy. But if Sweden fills the road with saltwater, then we've discovered that the surface level of electricity is only one volt. Sweden could walk itself barefoot on it.

2. Review of Literature

Energy generation using solar photovoltaic needs a significant amount of space. If the cost of the land rises day by day there is a clear need to use the available land as effectively as possible. Here, we explored the feasibility of energy generation using the land above national road highways by constructing a roof structure. This space will contribute to the energy generation without additional cost for the field. It also results in energy efficiencies, such as increased vehicle movement and minimal energy for the air conditioning of automobiles. Besides, it also helps with minimal road repairs and longer vehicle tire life due to the sunshade effect. As a result, the cost of wear and tear for road maintenance is greatly reduced. Our modeling study shows that the Ahmedabad-Rajkot highway can generate 104 MW of electricity (163 GWh of annual energy generation) and the Ahmedabad-Vadodara highway can generate 61 MW of electricity (96 GWh of annual energy generation) for single-layer solar panels. Solar Power generation capacity along national highways developed by Pragya Sharma [6]. She worked on the Ahmedabad-Rajkot highway can generate 104 MW of electricity (163 GWh of annual energy generation) and the Ahmedabad-Vadodara highway can

generate 61 MW of electricity (96 GWh of annual energy generation) for single-layer solar panels. If there are two layers of solar panels on each other, the annual energy production of the same highways, Ahmedabad-Rajkot and Ahmedabad-Vadodara, can be increased to 229 GWh and 140 GWh respectively.

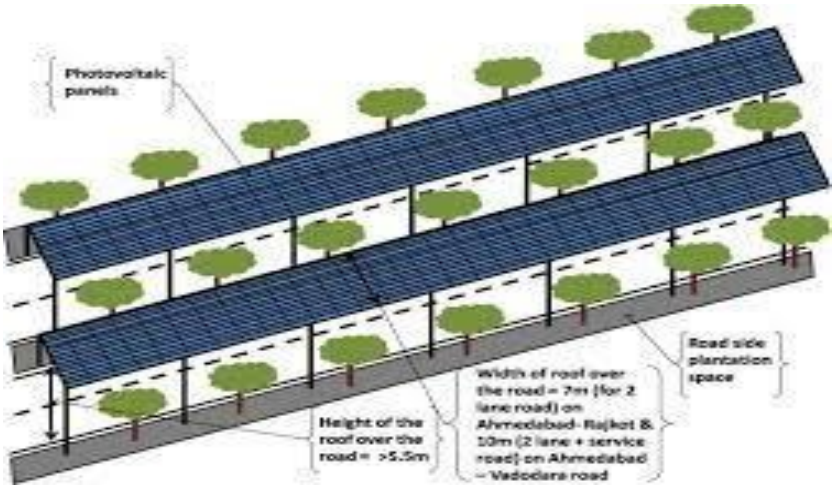
Photovoltaic panels
Road side plantation space
Width of roof over the road = 7m (for 2 lane road) on Ahmedabad- Rajkot & 10m (2 lane + service road) on Ahmedabad – Vadodara road
Height of the roof over the road = >5.5m

Fig 9- Ahmedabad-Rajkot highway (Source : springerlink.com)

Enhancing electricity generation from two-layer solar panels developed by Tirumalachetty Harinarayana [7]. His work on Two-layer solar panels showed an efficiency increase of about 75% compared to a single layer solar panel. A new route for the construction of smart highways using photovoltaic solar panels developed by Abhishek Rajendra Patila [8]. He worked on microprocessor-based technology .electricity generation from solar energy developed by Sirajuddin Shaikh [9]. He had reviewed Sunlight Solar Energy explored their future trends and aspects. Optimization of mono-crystalline solar panels using reflector scanning technology developed by Abu Hasan Fiqri Al Faruqi et.al [10]. They worked on Determine the output voltage and current generated by the installed solar panels. The reflector is used to maximize the exposure of solar radiation to solar panels. Data from the output voltage produced can be obtained by direct analysis using without reflector solar panels and within reflector solar panels. . Polycrystalline PV modules are usually made up of a variety of different crystals, coupled together in a single cell.

Fig 10-Mono-crystalline solar panel (Source : https://www.sciencedirect.com)

Solar Cells studied by Kamlesh Kumar Jain [11]. He had reviewed an advanced creation of solar cell research from one generation to the next and explored their future trends and aspects. Polycrystalline PV modules are usually made up of a variety of different crystals, coupled together in a single cell. The manufacturing of polycrystalline Si solar cells is more economical, which are produced by coolinga graphite mold containing molten silicon. Polycrystalline Si solar cells are currently the most common solar cells in the world. It is believed that they would occupy up to 48 percent of the world's solar cell production in 2008 [12].High efficiency 17-20% of a mono-crystalline solar panel. When the sunlight falls on the monocrystalline solar panel, the cells absorb the energy and generate an electrical field through a complicated process. This electrical field comprises voltage and current and generates power regulated by equation P (power) = V (voltage) x I (current). This power can be used directly to power devices running on direct current (DC). This power can also be transformed into alternating current (AC) by using an inverter

Fig 11-Polycrystalline solar panel (Source : https://economictimes.indiatimes.com)

To make solar cells for monocrystalline solar panels, silicon is molded into bars and cut into wafers. These types of panels are named "monocrystalline" to show that the silicone used is single-crystal silicon. Since the cell is made up of a single crystal, the electrons that produce a flow of electricity have more freedom to pass. Monocrystalline panels are therefore more efficient than their polycrystalline counterparts. The microgrid is a community of interconnected loads and distributed energy resources within clearly specified electrical boundaries that act as a single controllable entity to the grid. A microgrid is a decentralized gathering of power sources and loads that ordinarily work associated with and simultaneous with the conventional wide zone coordinated lattice (microgrid), however can likewise disengage to "island mode" — and work self-sufficiently as physical or financial conditions direct. Microgrid development using a grid-tie inverter developed by Hartono Budi Santoso1 and Budiyanto et.al [13]. They worked on the Possibility of saving power consumption from the grid by using the GTI (Grid Tie Inverter) in a microgrid configuration. The test is conducted using zero load and power distribution methods. Test results show the GTI grid connection capable of supplying electricity to the grid up to 98% of the input power converter. In the microgrid configuration, the power demand from the grid can be reduced to 91 percent, which should be supplied from the grid for loading.

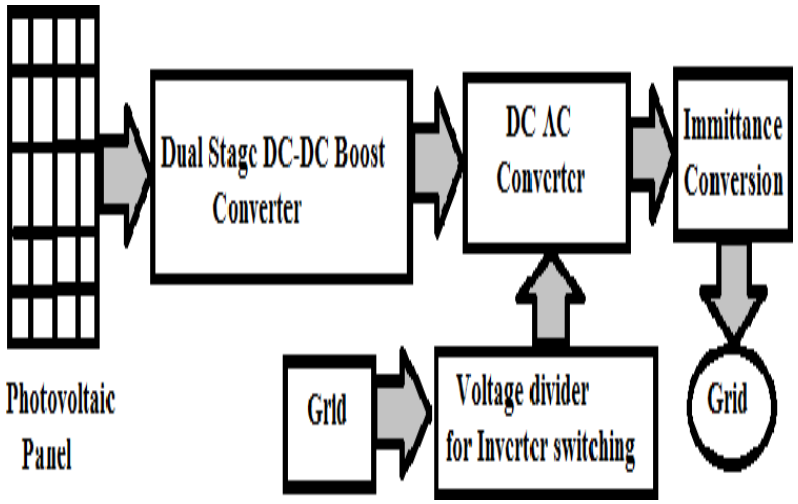

Fig 12-Block diagram of GTI (Source : https://www.researchgate.net)

Wind/Solar Hybrid Generation-Based Roadway Microgrids developed by Anuj Sharma, Jerry [20] they worked on It operates as a smart microgrid that optimally utilizes the public right-of-way and roadway infrastructure to provide a cost-effective, highly efficient, and reliable wind/solar electric power production, distribution, storage, and utilization. The fundamental unit of the microgrid is called the energy-plus roadway/traffic signal light (EPRTL), which contains a grid-connected wind/solar hybrid generation system installed on the pole of a roadway/traffic signal light for clean electric power production. The term "energy-plus" stands for annual energy consumption that is less than production. The generated electric power will be consumed locally by the roadway/traffic signal light; the excess power generated will be stored in batteries, optimally distributed in the microgrid, and supplied to the utility main grid. The deployment of the proposed roadway microgrid will dramatically change the roleof the public right-of-way from an energy consumer to an energy producer, leading to energy-plus roadways. This will not only reduce the roadway agency operating costs but also generate new revenues for the Highway Trust Fund. The use of renewable electric power will also promote the development of green roadways. The breeze/sun-powered cross breed age framework utilizes wind/sun based assets to produce electric force, which is circulated through the street microgrid. A force gadgets based electric force transformation framework is served as an interface between the EPRTL and the lattice. This force gadgets interface changes over the electric force created into the structure needed by

the force framework and nearby burden, for example, the wanted voltage level and recurrence (60 Hz

in the Assembled States). A discretionary energy stockpiling framework, e.g., a battery, could be utilized as a source or sink of the electric capacity to control the force traded between the EPRTL and the microgrid. The utilization of energy stockpiling empowers the street microgrid to work in island mode to consistently supply high-quality electric capacity to the heaps during possibilities of the utility primary network. The entire process of the electric power production, distribution, storage, and utilization of the EPRTL is controlled by a local power management controller (LPMC) and coordinated by a supervisory power management controller (SPMC) at the microgrid level, depending on the power management strategy adopted for the mc

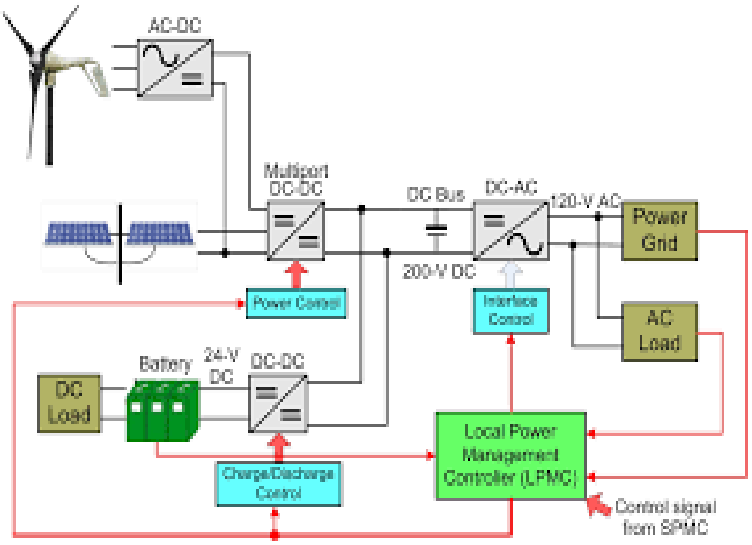

Fig 13-The configuration of an EPRTL connected to the roadway microgrid. (Source :http://energyplusroadways.unl.edu).

Design and Development of 5MW Solar PV Grid Connected Power Plant Using PVsyst developed by, Dr. S. Kumarappa [21] he worked on the lattice associated sunlight based photovoltaic force plant at the spot called Belakavadi of Mandya region in the condition of Karnataka set up by Karnataka Force Company Restricted in the year 2012. The photovoltaic force plant has a sunlight based radiation of 6.10 kWh/sq.mt/day spread more than 25 sections of land. Working module temperature differs from 15 to 40 degrees centigrade, with a tilt point of module 15 degree and ensured energy created is 8.142 MU/Annum with 18.6% CUF. The different force misfortunes (PV misfortune because of illumination level, temperature, ruining, inverter, wiring, power hardware, lattice accessibility, and interconnection) and execution proportion are determined. From recreation giving a yearly PR of 84.4%.and too 25,615.6 Kg's of coal saving every day at the creating point by introducing 5MW sun-powered plant.

This establishment will be equal to planting 246,000 teak trees throughout the existence time. Florida solar energy system developed a grid-connected PV system [22]. his work on a framework associated photovoltaic framework, or network associated PV framework is a power-producing sunlight based PV power framework that is associated with the utility lattice. A lattice associated PV framework comprises sunlight based boards, one or a few inverters, a force molding unit, and matrix association gear.

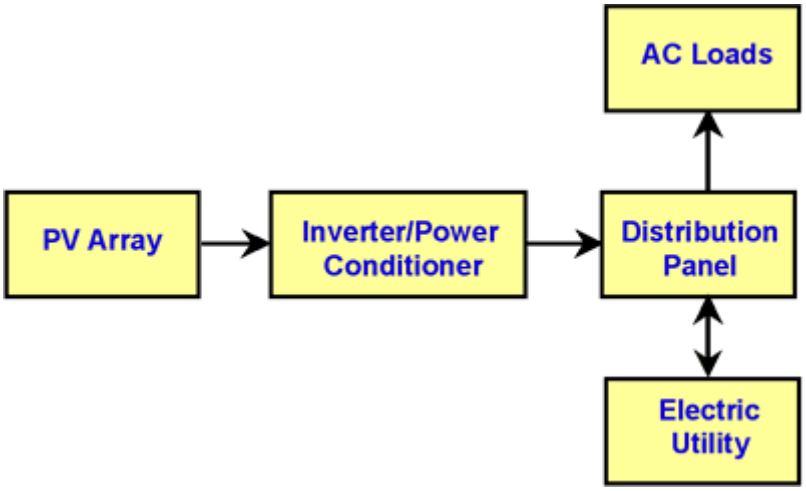

Fig 14- The block diagram of PV systems (Source : resarchgate.com)

In the control perspective, incorporation of distributed energy resources developed by Chowdhury [23] his work represent on incorporate microgrid successfully in real power scenarios, the integration of distributed energy resources, operation, control, power quality issues, and microgrid system stability should be explored. Coordination and control clusters of microgrids developed by Bandeiras [24] focused on control and energy management. Renewable Power Micro-grid system is based Units for Generation developed by Dr.K.Ravichandrudu [25] was using Matlab / Simulink to define the technical problems involved in running a micro-grid system based on renewable power generation units. A small-signal micro-grid dynamic model of traditional and electronically interconnected distributed capital developed by M.R. Iravani [26] approach the model reflects (i) the electro-mechanical dynamics of the synchronous unit, including the exciter and the controller structures, (ii) the dynamics of the converter and its

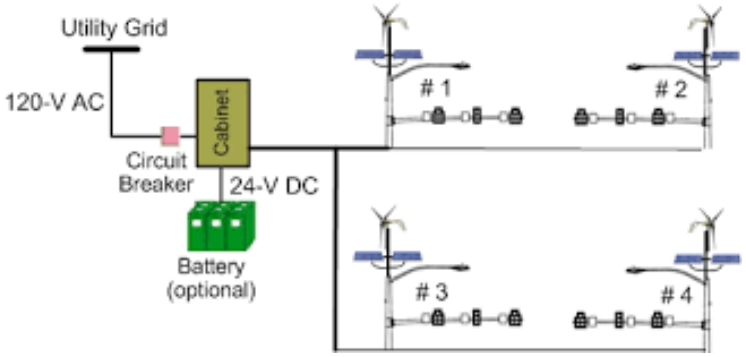

Fig 15-EPRTL connected to the roadway microgrid (Source : digitalcomms.unl.edu)

Real/reactive power controllers, and (iii) the dynamics of the network. Generation-Based Wind/Solar Hybrid Microgrids for Roadways developed by Anuj Sharma[27] his work represent a wind/solar hybrid generation system connected to the grid mounted on the roadway/traffic signal light pole for the development of renewable electricity. Technology from DC Microgrid was developed by Dinesh Kumar [28]. his approach DC Microgrid Software Standardizations. Assessment of the distribution of 400V DC in telco and data centers to increase energy efficiency developed by Pavan Kumar [29] An empirical evaluation of several power delivery architectures of data centers over a range of loads shows that the most effective is a 400 V facility-level DC distribution option. Consideration of voltage spectrum for international standardization of a 380 VDC distribution system developed by Keiichi Hirose [30]. His work on the design of power systems, equipment, devices and services, voltage levels as well as nominal voltagesis an essential concern. Harmonic mitigation analysis with the use of hybrid passive philters developed by Firuzzare [31] his work for different configurations of passive components, a comparative study was carried out and a hybrid passive filter was eventually designed for harmonic mitigation. Pulse Pattern-Modulated Three-Phase AC-DC Converter Strategy for Harmonic Current Components Reduction developed by Pooya Davari [32]. He is Using a single-switch boost tri-phase diode-bridge rectifier, a novel current modulation technique. Impact of voltage level selection on LVDC distributionsystems earthing and safety developed by J.Karppanen [33]. This paper focuses on the consequencesof D.C. Option of mains voltage level for earthing and safety of the distribution system for low voltage direct current (LVDC). Microgrid from Solar-dc for Indian Homes developed by PrabhjotKaur [34]. It is well known that energy access is closely related to socio-economic growth. Identification of Multi- Input DC-DC Converter Feasible Topologies developed by

Alexis Kwasinski [35]. The study is focused on a variety of theories, constraints, and conditions, including the objective of reducing the total number of components and using at least one forward-conducting bidirectional blocking switch in each input leg. Fault Position using active impedance estimation in a Zonal DC Marine Power System developed by Mark Sumner [36]. The' fold back' method is an example of a technique built to take advantage of the rapid control of the power converters to maintain bus currents at appropriate levels. Grounding DC traction power system developed by D, Paul [37]. An overview of the grounding of equipment, device grounding, and their relationships is extracted to achieve optimized equipment and personal protection. Distribution of Low-Voltage Direct Current in a Utility Network System, Functions, and Operation developed by TeroKaipia [38]. To demonstrate the key functionalities and other essential device properties, experience of use, and measurement results are given. Mitigation of voltage unbalance using a boost-SEPIC form interleaved dc-dc compensator in a low voltage bipolar DC microgrid developed by Vivek Agarwal [39]. The proposed method decreases the neutral line current, thus decreasing the total line losses in the microgrid of bipolar dc. Plug-In Electric Vehicle- Design and operation of microgrid with renewable energy sources and energy storage system developed by shah Zeb [46]. He worked on the efficient use of energy sources with a classified load distribution system. The results of this research clearly show the cost-effectiveness of microgrids compared to the reliance on the power grid. Grid Connections Evolution was developed by Ross Baldick [40]. His work on PEV technology. evacuate from hurricanes with electric vehicles researchby Feng, K., Lin, N., Xian, S., & Chester [41] found The expanding utilization of electrical vehicles (EVs) probably won't meet the security prerequisite of gigantic tropical storm clearings, which may happen all the more as often as possible later on the atmosphere. Here we explore the test of generally utilizing EVs for tropical storm departure through examining the force interest during the immense verifiable clearing before Typhoon Irma (2017). We find that, if most of the emptying vehicles were EVs, Florida would confront a genuine test in force supply, with its six out of nine principle power specialists, particularly those in the mid-Florida, being shy of intensity during the departure cycle.

Fig 16--E.Highway (Source :https://www.volkswagenag.com)

Additionally, the force blackout in mid-Florida could prompt falling disappointment of the whole force network all through Florida. Innovative electric road freight transport developed by Scania [42] company worked on Electro portability offers an assortment of advantages, including improved neighborhood air quality, fuel expansion into reestablishing capable sources to decrease reliance on petroleum products, and expanded energy effectiveness, that lower working expenses. Given that few nations as of now have a low carbon emission. The public authority is dealing with an electric expressway between New Delhi and Mumbai at an expense of about Rs 1 lakh crore and has just granted 60% of the agreement for that, Nitin Gadkari, the association serves for street transport and roadways, said. "It will be a 1,300 km, 12-path green interstate, and our objective is to finish it before January 26, 2024," he said uninvolved of an occasion coordinated by TVS Engines to check its entrance into the electric trucks fragment. Electric vehicle charging infrastructure planning in a road network developed by Antonio Polimeni [47]. He worked on the distribution of services to host charging infrastructures. Using demand and supply through a two- level model, the locations initially defined and then the number of charging stations for each service area were evaluated.

3. Need of the Study

Renewable energy systems are a globally accepted solution to effectively mitigate pollution in the energy sector. SPV Plants are popular in India owing to the availability of Sun for a larger number of hours during the entire year. Besides, the requirement of low maintenance, high reliability, and moderate initial cost also makes SPV plants a favorable choice. However, Energy generation using

solar photovoltaic needs a significant amount of shade-free space. A thumb rule used by designers is toconsider 10 sq.m space for a plant capacity of 1 kWp. The cost of the land is ever increasing and there is an emergent need to use the available land as effectively as possible. The highway provides an avenue for installation of SPV Plant on spare land available on the center divider as well as either side of the road. This will increase the land utilization of highways and they will also play a role in energy generation. Such highways can reduce pollution index directly by facilitating electric vehicle movement and indirectly by contributing to green energy generation. Though the land requirement of SPV plant and under-utilized land on highways in principle seems to satisfy the requirements, conventional SPV plant topologies are not suitable for deployment for proposed applications. Further, evacuation of energy to grid and catering to loads is different from conventional SPV Plant. Hence, a novel topology of the SPV plant, a suitable method for energy evacuation must be designed. The efficacy of such a system is required to be studied through its performance on realistic working scenarios. This work is envisaging to conduct the same.

4. Objective of Study

Based on the literature review, the following are the proposed objective of research work to be done:

- Design of Solar Photovoltaic Power Plant for deployment on the Highway.
- Typical SPV plants are of configuration where an inverter is fed from several SPV modules

through a suitable charging system. The inverter can directly feed the energy to the grid or it can store the energy in a battery. Besides feeding back to the grid it feeds the load on a pre- decided priority. However, an SPV plant on the highway would require a novel deployment scheme despite having a similar configuration. The panels would have to be laid out in a row resulting in longer cable lengths and more voltage drops before the energy reach inverter. Evacuation is also going to have issues as it is not necessary to have loads uniformly distributed over the length of the highway. Hence, conventional SPV system design cannot be deployed as it is, but a novel topology must be designed which is proposed in this work.

- Evaluation of the energy generated.

  Besides novel topology, a method to evacuate energy must be designed. With the SPV plant spanning over kilometers, evacuation infrastructure is needed to be designed. concentrated loads

over the span of highway, main grid are possible avenues and a judicial mix that can be advantageous has to be determined, which is proposed in this endeavor.

- Applications:

It is proposed to simulate and verify the operation of a system with concentrated stationary loads SPV system. These loads can be

1. AC loads representing existing toll booths, eateries, etc.
2. DC charging stations for electrical vehicles
3. Highway Illumination

A Novel Concept of charging lane on a highway is also proposed to be investigated. The solar photovoltaic plant can provide the power supply over the entire span of the highway and hence can provide support to a novel electric vehicle charging system. In this system, it is proposed to designate a separate line for charging where an electric vehicle can travel with a pantograph arrangement to charge while moving. Once a requisite state of charge is achieved, the vehicle can leave the charging lane and move on to other lines. This provides a scenario where the entry location of the electric load is not fixed as well as the load is moving over the length of the line. In the present work, it is proposed to study the system.

5. Hypotheses of Study

- The work proposed will provide an answer to the installation of large sized SPV plants near to load centers without acquiring new land.
- This work will provide a study that will be beneficial in achieving the target of 100 GW renewable energy generation in India.
- Renewable energy plants would help in reducing CO_2 emissions and ensure a sustainable supply of electricity.
- Availability of electric energy sources on the highway would give impetus to intercity travel using electric vehicles and thus help in the reduction of vehicular pollution.
- The proposed system will support reducing vehicular pollution but also boost the economy of the nation through

- Energy supply

Giving impetus to a new paradigm of intercity electrical vehicles.

6. Scope of work

The following work is proposed in this endeavor.

1. Design a Solar PV based systems for deployment on Highways to harness Solar Energy without affecting the traffic on the highways
2. Design a suitable energy evacuation system on highways
3. Design and simulate an efficient electric lighting system for highways
4. Design and simulate vehicle charging station for Electric Vehicles
5. Design and Simulate the concept of e-highway with charging lane
6. Integrate the SPV plant with specified loads to develop a comprehensive model of theproposed system.

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